Policy instruments, subsidies and value of agricultural production: Mexico, Brazil and Chile

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Abstract

Transfers, in the form of subsidies, are a government intervention aimed at boosting economic development. These are provided through various instruments that affect production and trade. The Organisation for Economic Co-operation and Development classifies these instruments into categories from most to least distorting. In its strategy of deregulating the world market, it encourages the use of the latter in agricultural policy. Nonetheless, the effect of this recommendation on the value of agricultural production has been poorly researched. This work assessed the relationship between the amounts of support in different agricultural policy instruments used and the value of the production of subsidized agricultural products (VpS) in Mexico, Brazil, and Chile during the period 1995-2020, through a multiple linear regression model with the stepwise backward elimination procedure. The results show that the transfer items that were relevant to explain the VpS in Mexico were: storage, marketing and other physical infrastructure, support based on area and number of animals, extension services, safety and inspection of agricultural products and institutional infrastructure ($p < 0.05$), in Brazil they were: research, market prices and education ($p < 0.05$) and in Chile they were: research, storage, marketing and other physical infrastructure, and farm restructuring ($p < 0.05$). It should be noted that all instruments with a significant effect on the VpS are classified as less distortive, except for the market price support present in Brazil.

Keywords:

agricultural policy instruments, general service support estimator, producer support estimator, transfers.

Introduction

Public spending on agriculture is mainly focused on direct transfers to the producer, encompassing subsidies for inputs, capital, and other agricultural services. In addition, transfers are allocated to public goods with the aim of improving the performance of the agricultural and rural sector (Zavala-Pineda *et al.*, 2015; OECD, 2022a). The World Trade Organization (WTO) highlights that agricultural subsidies serve as a tool for governments to achieve various policy goals (WTO, 2006).

In this context, authors such as Dewbre *et al.* (2001) underline the importance of ensuring reasonableness in the amounts and allocation of subsidies, considering the nature of the support and its relevance, stressing the need for an effective and appropriate allocation of resources. The literature on agricultural support suggests that the higher the amounts linked to production levels or price, the greater the incentives to increase or intensify production, generating greater potential trade distortions (Bielik *et al.*, 2007; Effland, 2011; OECD, 2022a).

Therefore, decoupling subsidies from production appears to be a key strategy to reduce trade disruptions (OECD, 2001; Anton, 2004). Following the WTO agreement to reform the world agricultural market, two systems have been established to measure and classify the level of support, thus facilitating the comparison, monitoring, and evaluation of the continuity of policy reforms across countries.

The WTO (WTO, 2006) and the OECD (OECD, 2016) developed similar classification systems, where the former was aimed at strengthening member countries' trade negotiations and the latter at assessing structural changes in the national agricultural policies of member countries and other important market participants. The classification system of support instruments developed by the OECD was established considering the support approach and was categorized according to destination (producers, consumers, and general services in the agricultural sector) (Effland, 2011; OECD, 2022a).

The OECD (2016) classifies agricultural policy instruments into three main indicators: producer support estimator (PSE), general services support estimator (GSSE) and consumer support estimator (CSE), considering those included in the PSE indicator as the most distorting instruments. Through these three indicators and the policy instruments that each of them incorporate, countries' total support to agriculture (TSE) is channeled.

The OECD (2022a) indicates that the total support to agriculture (TSE) of the 54 countries it assesses exceeded 700 billion dollars in 2021, representing just over 18% of the total value of production generated by the sector. In this context, developed countries, including the United States of America, the European Union, Japan, Switzerland, and Norway, are the largest subsidizers, in contrast to developing countries, where farmers receive domestic support amounts up to ten times lower compared to their counterparts in developed nations (Erokhin *et al.*, 2014; OECD, 2022a).

In 2021, the subsidies transferred through the instruments categorized in the PSE and GSSE components accounted on average for 88% of the total agricultural subsidies granted in that year (75 and 13% of the total transferred, respectively). Despite the OECD policy prescription, which recommends that the principal amount of agricultural transfers be made primarily through the use of the GSSE instrument group (OECD, 2016; OECD, 2022a), there is little quantitative evidence to show the effects of policies using the least distorting instruments on the value of agricultural production.

In this sense, economic theory would suggest that the use of the instruments included in the GSSE indicator would make agricultural production and trade more efficient (OECD, 2022a). However, few quantitative studies have been conducted demonstrating the effect of policy instruments on agricultural performance in various countries (Bielik *et al.*, 2007; Jong and Jensen, 2007; Gallacher and Lema, 2014; Arisoy *et al.*, 2017; Arisoy, 2020) on the behavior of the value of the production of the subsidized products.

It is essential to note that a large number of LAC countries are exporters of agricultural products, being one of the most important sectors due to its role as a source of foreign exchange, as is the case of Brazil, Argentina, Mexico and Chile (Gurria *et al.*, 2016; Morris *et al.*, 2020).

Due to the above, it is important to analyze the effect of the amount of support, as well as the agricultural policy instruments classified within the PSE and GSSE groups, on the value of production of the main subsidized products in Mexico, Brazil and Chile, through an econometric analysis that generates arguments that support the design of the policies applied to the sector.

Materials and methods

The information used consisted of a 26-year time series corresponding to the period 1995-2020, which was obtained from the database of the Organisation for Economic Co-operation and Development (OECD, 2022b). The series contains information on the value of production of subsidized products and the amount transferred through various agricultural policy instruments in Mexico, Brazil, and Chile.

The subsidy amounts and the value of production were obtained at nominal prices and in national currency, so they were deflated to obtain them in real terms, monetary base 2020. For this purpose, we used the Consumer Price Indices (CPI), which were obtained from the statistical institutes of each country (Banco de México, 2022; Instituto de estadística de Brazil; Instituto de Estadística de Chile, 2022).

Defining variables

The variables selected for this analysis include the value of production of agricultural products subsidized by Mexico (wheat, barley, corn, sorghum, rice, soybeans, tomatoes, beans, coffee, sugar, milk, beef, pork, and chicken), Brazil (wheat, corn, rice, soybeans, coffee, cotton, beef, pork, and chicken), and Chile (wheat, corn, sugar, milk, beef, pork, and chicken) and the agricultural policy instruments applied by each country. These types of instruments are described in the methodology for the evaluation of the producer support estimator (PSE), which was developed by the OECD (2016).

Support instruments are classified into two groups, those that go directly to the producer (PSE) and the general service support estimator (GSSE), which are payments to private or public services provided to agriculture in general. When reference is made to the agricultural sector, all agricultural and livestock activities are included, forestry and fishing activities are not considered. Both groups of instruments are subdivided into categories, which are identified from A to L. This classification can be found in more detail in the document of the OECD (2016).

Econometric model

The model considers the effect of the amount and instruments used in each country's agricultural policy (PSE and GSSE) on the value of production of subsidized products (Table 1). The contemporaneous relation of y explained by the x's was modeled; such a model is postulated when a change in *x* at time *t* is considered to exert an effect on *y*. Specifically, the model is defined by:

$$VpS_t = f(A_t, B_t, ..., L_t) + u_t$$

(equation 1).

Variable	Instrument	Coefficient	Standard error	t	$p > t$
B1	Support for variable inputs	2.163	1.257	1.72	0.102
E	Payments based on historical A/An/R/I[1], production not required	-5.929	1.013	-5.85	0[***]
H22	Extension services	-190.974	44.121	-4.33	0[***]
I1	Safety and inspection of agricultural products	95.122	33.089	2.87	0.01[**]
J2	Storage, marketing, and other physical infrastructure	636.669	258.686	2.46	0.024[*]
J3	Institutional infrastructure	-61.506	21.881	-2.81	0.012[*]
J4	Farm restructuring	44.607	29.89	1.49	0.153
	Constant	519094.5	22427.07	23.15	0[***]

Table 1. Results of the model for Mexico.

[1] = payments based on historical A/AN/R/I*, production not required. [*]= $p < 0.05$, [**]= $p < 0.01$, [***]= $p < 0.001$. Based on Stata 17 output.

The model postulates that the behavior of the variable VpS_t (Value of production of subsidized products) can be explained by the different predictor variables, which are the amounts and instruments used by the agricultural policy of the countries plus an error term u_t that includes the joint effect of other variables not included in the model, so its effect is considered not relevant; as it is a macro-level model with an annual periodicity, it is assumed that there is no correlation of observations over time. The choice to use this model was justified considering the limitations in the availability of detailed data, the number of variables used, and the specific nature of the information collected.

Procedure

To analyze the data, the stepwise procedure was performed, which allows building the model from a set of candidate predictor variables by entering and eliminating predictors sequentially until achieving a model with good fit and parsimonious (StataCorp, 2017).

This method has been used in various studies, such as those of Happe *et al*. (2006); Żogala-Siudem and Jaroszewicz (2021); Bataineh *et al*. (2022); Gao *et al*. (2022), with the purpose of identifying the most influential factors in the characteristics of agricultural products and analyzing political and migratory effects.

To review the model's validity assumptions, variance inflation factor (VIF) tests were applied to analyze the multicollinearity assumption, where if the VIF for each term is less than 5, it indicates that there is no dependence between the regressors; otherwise, if there are one or more large VIFs, the problem of multicollinearity arises (Pehlivanoğlu *et al*., 2021).

To test the presence of homoscedasticity, White's test was applied, which states that if the *p*-value> 0.05 (not statistically significant) then there is homoscedasticity, conversely, if the *p*-value< 0.05, there is the presence of heteroscedasticity (Wooldridge, 2010). Validation of the normality test was performed using the Shapiro-Wilk test, where if the error is distributed normally, the *p*-value is

greater than 0.05 (probability of making type I error). In order to make the aforementioned statistical estimates, the Stata Statistical Software was used (StataCorp, 2017).

Results and discussion

In Mexico, total support for agriculture decreased from 2.6% to 0.58% of GDP during the period analyzed, as did in Brazil, where it went from 0.72% to 0.56%, and in Chile, from 0.64% to 0.28%. This performance reflects a trend consistent with most OECD member countries (Arisoy *et al.*, 2017). As for the Producer Support Estimator (PSE), expressed as a percentage of the value of agricultural production, Mexico experienced a reduction from 31% to just over 9%, Brazil decreased from 7.5% to 1.5%, and Chile went from just over 7% to 2.5% (OECD, 2022a).

Support based on the production of basic products, such as market price support, is the most distorting instrument in the agricultural market. It includes measures such as minimum prices, quotas, tariffs, and taxes, generating a differential between the reference price and the producer price (Lema and Gallacher, 2015). At the beginning of the period analyzed, these instruments accounted for approximately 84% of transfers to producers in Mexico, 35% in Brazil, and 61.5% in Chile. At the end of the period, these figures changed to 53.5%, 36%, and 2.25%, respectively, for the year 2020.

In addition, it was observed that support for inputs became more relevant in the period analyzed in Chile, going from 17% to 94% as a percentage of support to the producer. In Brazil, this instrument increased from 1% to 59%, while in Mexico, despite a 15% decrease at the beginning of the period, it stabilized at 13% by 2020. It is clear that Brazil and Chile attach greater importance to this type of instrument compared to Mexico (Figure 1, panel a).

Figure 1. Percentage performance of agricultural policy instruments. Panel a y b)= producer support instruments; c and d)= general service support instruments; A/An/R/I= area/animals/receipts/income. Based on the data base of OECD (2022a).
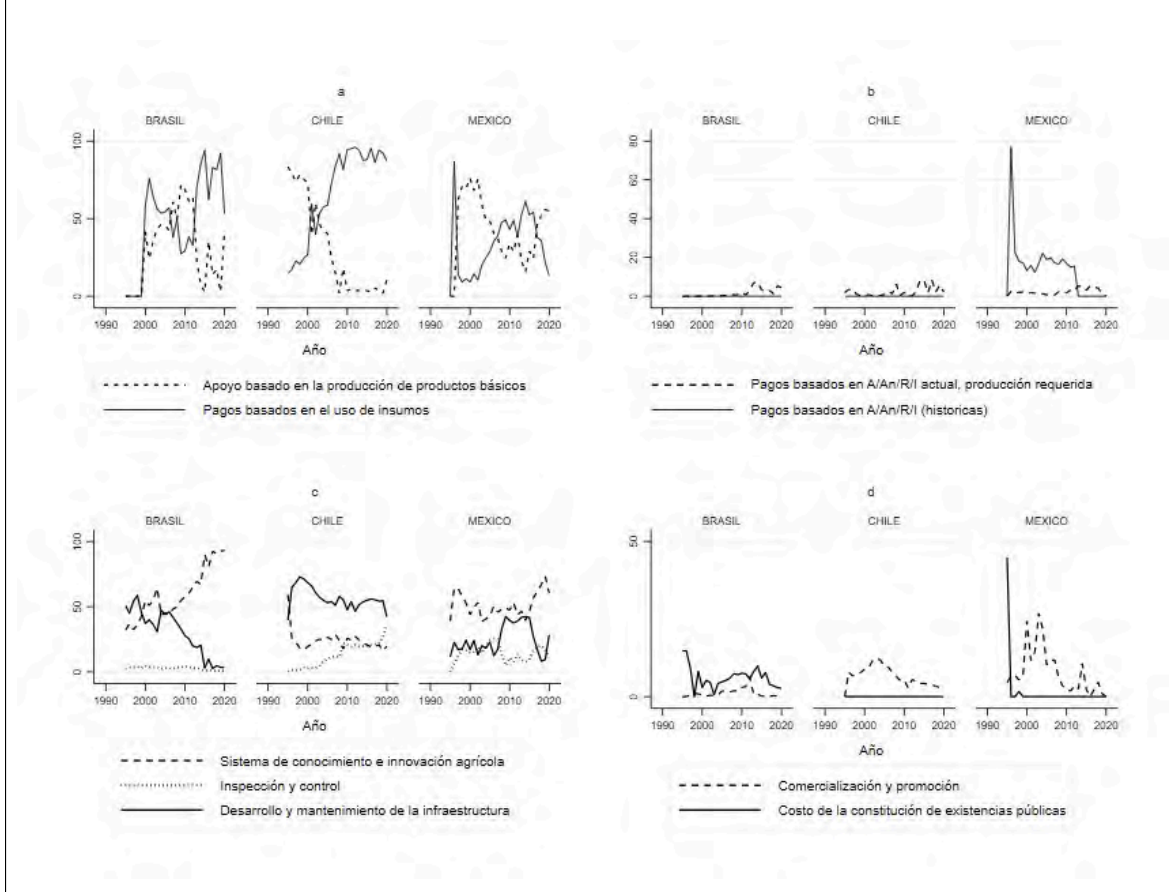
The OECD (2001) indicates that category A and B agricultural policy instruments affect resource allocation in all agricultural products due to their cross-effects on supply. Dewbre *et al.* (2001) point out that these supports are less efficient in benefiting agricultural households and more favor producers with a favorable productive context. In Mexico, payments based on area/animals/ receipts/income are presented through the PROCAMPO program, which emerged after the entry into force of NAFTA as a compensatory program for structural change in the Mexican economy. This type of support has not been relevant in Brazil and Chile.

The budget allocated to general service support instruments has decreased in Mexico, from 9% to 8.7% as a percentage of support to the agricultural sector. By contrast, in Brazil and Chile, the budget allocated to this group of instruments has increased by about 3% for Brazil and more than 30% for Chile (OECD, 2022a). In Mexico and Brazil, the main item supported by this group is the agricultural knowledge and innovation system, which includes support for extension and education. Nonetheless, Mexico has experienced a cut at the end of the period, while in Brazil the amount transferred continues to increase.

For Chile, the most important item in this group is the development and maintenance of agricultural infrastructure, while in Brazil it has decreased over time and in Mexico it shows a fluctuating but upward behavior. Inspection and control support, which is essential for complying with international trade rules, has a percentage of support lower than other instruments. The marketing and promotion support instrument is used in all three countries analyzed, but its share is close to zero. Regarding the instrument of cost of public stockholding, it is almost zero in Mexico and Chile, while in Brazil, at the beginning of the period, it represented about 18%, decreasing to 4% at the end.

Effect of agricultural policy instruments on the value of production

The estimation of the econometric regression model for Mexico using the stepwise procedure complied with the assumptions of statistical validity. The variance inflation factor (VIF) for each term was less than 5, indicating the absence of multicollinearity problems. In addition, when applying White's test, a *p*-value of 0.407 was obtained, suggesting the presence of homoscedasticity ($p > 0.05$).

Finally, when applying the Shapiro-Wilk test, a *p*-value of 0.402 was obtained, indicating that the model follows a normal distribution since $p > 0.05$. The coefficient of determination R^2 shows a goodness of fit of 90, meaning that the independent variables (policy instruments) explain 90% of the variations in the dependent variable (VpS).

In relation to variable E, it is presumed that it acts as an instrument that distorts the market to a lesser extent and may generate a negative effect, as indicated by Morris *et al*. (2020). These authors point out that payments of this type, since they do not require production, motivate farmers to generate products whose value is not less than the costs of production. In addition, they offer a more efficient way to support farmers' incomes, which could result in producers leaning towards higher-value crops.

Regarding variable H22, Ramirez *et al*. (2022) point out in their study that extension workers tend to have a late contracting system, which is reflected in the delay of their activities and limits the set of innovations they can transmit. In addition, they face administrative constraints, as well as uncertainty regarding payment and continuity of service. On the other hand, variable J3, which deals with support for producer organization, shows a negative effect.

Gómez and Tacuba (2017) argue that it is crucial to promote efficient solutions in terms of organizational schemes to facilitate links with other sectors. Nevertheless, in Mexico, the lack of coordination among farmers negatively affects the efficiency and competitiveness of the sector. In addition, the lack of a solid production linkage limits synergies between the links in the production chain, affecting the profitability and sustainability of agricultural operations. Solving these problems represents a crucial challenge to improve productivity and strengthen the sector's position in the economic landscape.

Regarding the variables that positively impact the value of production, there are safety and inspection of agricultural products (I1), storage, marketing, and other physical infrastructure (J2) and farm restructuring (J4). Variable I1, which covers transfers to SENASICA, the government agency responsible for controlling food quality and animal and plant health, as well as agricultural inputs, plays a crucial role for the sector.

These transfers offer the possibility of certifying the production and labor process, increasing export opportunities (Jana, 2008) and therefore, improving the value of agricultural production. As for the transfers recorded in variable J2, which include support for livestock infrastructure, they generate an efficient impact on production by supporting the improvement of facilities, which translates into an improvement in production (Kimura *et al.*, 2010).

Finally, variable J4 (farm restructuring) corresponds to the capitalization and investment fund for the rural sector (FOCIR, for its acronym in Spanish), focused on the capitalization of the rural and agro-industrial sector, encouraging the participation of the private sector and national and foreign financial agents (FOCIR, 2022). According to Ackermann *et al*. (2018), developing relations of reciprocal cooperation with public and private institutions, national or foreign, and with international organizations allows the optimal use of available resources for the benefit of the countries that achieve this linkage.

The model for Brazil met the assumptions of multicollinearity, heteroscedasticity, and normality. The variance inflation factor (VIF) for each term was less than 5. When applying White's test, a *p*-value of 0.08 ($p > 0.05$) was obtained, indicating the existence of homoscedasticity. Finally, when performing the Shapiro-Wilk test, a *p*-value of 0.37 ($p > 0.05$) was obtained, suggesting the normality of the data.

The coefficient of determination R^2 shows a goodness of fit of 90, indicating that the independent variables market price support (A1), research (H1) and education (H21) explain 90% of the variations in the dependent variable (VpS, Table 2). The results obtained from the model indicate that variable A1 acts as the producer support instrument that positively affects the dependent variable in Brazil, since the country continues to apply tariffs on trade.

Table 2. Results of the model for Brazil.

Variable	Instrument	Coefficient	Standard error	t	$p > t$
A1	Market price support	1.694	0.552	3.07	0.006***
H1	Research	76.257	5.775	13.2	0***
H21	Education	-200.383	92.723	-2.16	0.042*
Constant		112985.4	65390.3	1.73	0.098

$^* = p < 0.05$, $^{**} = p < 0.01$, $^{***} = p < 0.001$. Preparation based on the output of Stata 17.

This type of border measures continues to be a point of negotiation in the agreements with Ecuador and MERCOSUR (Frohmann *et al.*, 2020). On the other hand, variable H1 has a greater impact on the dependent variable compared to A1. This finding coincides with what was mentioned by Luna Morales *et al.* (2013); Morris *et al.* (2020), who point out that Brazil has focused its investments on research, collaborating with various international centers, with the collaboration with China standing out. Regarding variable H21, a negative relationship with the value of production was observed. This could be explained by the trend towards the privatization of education in Brazil, as noted by Dias and Brito (2008).

The regression model for Chile (Table 3) is valid as it meets the assumptions of multicollinearity, heteroscedasticity, and normality. The variance inflation factor (VIF) for each term was less than 5. When applying White's test, a *p*-value of 0.4 was obtained, which indicates that $p > 0.05$, showing the existence of homoscedasticity. Finally, when performing the Shapiro-Wilk test, a *p*-value of 0.91 was obtained, indicating a normal distribution.

Table 3. Results of the model for Chile.

Variable	Instrument	Coefficient	Standard error	t	$p > t$
H1	Research	43.316	4.095	10.58	0***
J2	Storage, marketing, and other physical infrastructure	1 449.942	544.945	2.66	0.014*
J4	Farm restructuring	-10.589	4.105	-2.58	0.017*
	Constant	1183326	102044	11.6	0***

$^* = p < 0.05$, $^{**} = p < 0.01$, $^{***} = p < 0.001$. Prepared based on the output of Stata 17.

The coefficient of determination R^2 shows a goodness of fit greater than 0.90, implying that the independent variables research (H1), storage, marketing, and other physical infrastructure (J2), and farm restructuring (J4) explain a little more than 90 percent of the variations in the dependent variable (VpS).

The signs of the estimated parameters indicate that variables H1 and J2 positively affect the value of production of the products subsidized by Chile. This trend coincides with the situation in Brazil, as Chile has focused its efforts on research rather than restructuring its agricultural enterprises, as noted by Morris *et al.* (2020).

Scientific and technological cooperation between China and Chile has been outstanding since the signing of the agreement on cooperation in science and technology between the two governments

in 1980, which has benefited this sector over time, as indicated by Gong and Guo (2022). At the beginning of this century, Chile reduced its tariff-based border protection, allocating more than half of public spending to general services (GSSE), especially for agricultural innovation and knowledge systems, off-farm irrigation infrastructure, inspection and control, land access, and restructuring (OECD, 2022a).

In addition, Chile has opted for a continuous policy of implementing Free Trade Agreements, thus guaranteeing access to new markets for its products (World Bank, 2021). According to Lovo *et al.* (2015), when designing and implementing decoupled policy instruments, it is crucial to consider economic, social, and cultural factors in choosing which policies to use and how to implement them in a manner compatible with broader development and growth objectives.

Quiñonez-Salcido and Travieso-Bello (2020) showed that there is a positive relationship between public spending on agricultural research and education and the medium-term growth of the sector, generating a return one hundred times higher over a four-year period compared to other budget expenditures. Differences in the effects of agricultural policy instruments on the value of production between Mexico, Brazil, and Chile can be attributed to different contexts, policy approaches, and country-specific characteristics.

Conclusions

Detailed analysis of agricultural subsidies in Mexico, Brazil and Chile reveals a diversity of approaches and results, with a general trend of decreasing total support to agriculture. Although the most distorting instruments, such as those based on production and price, tend to decline, their impact persists significantly. Decoupling subsidies from production stands out as a key strategy for reducing trade distortions, although challenges remain in the effective allocation of resources.

The econometric analysis focused on Mexico, Brazil, and Chile highlights the importance of specific instruments to improve the value of agricultural production, with emphasis on support for variable inputs, extension services, market prices, research, and education. The negative significance of certain instruments suggests the need to consider budget cuts in these sectors, adapting policy to changes over time.

Each country has its own unique agricultural policies, influenced by unique economic, social, and cultural contexts. International cooperation, opening up to new markets, and investment in agricultural research and education emerge as key elements for effective policies. In summary, the management of agricultural subsidies must be carefully adapted to the specific circumstances of each nation, considering the diversity of products, actors, and challenges of the sector. The effectiveness of these policies is measured not only by the magnitude of financial support, but also by their ability to promote sustainability, equity, and comprehensive development of agriculture globally.

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Policy instruments, subsidies and value of agricultural production: Mexico, Brazil and Chile

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